

Appomattox River TMDL Development

Final Public Meeting
3/11/2004



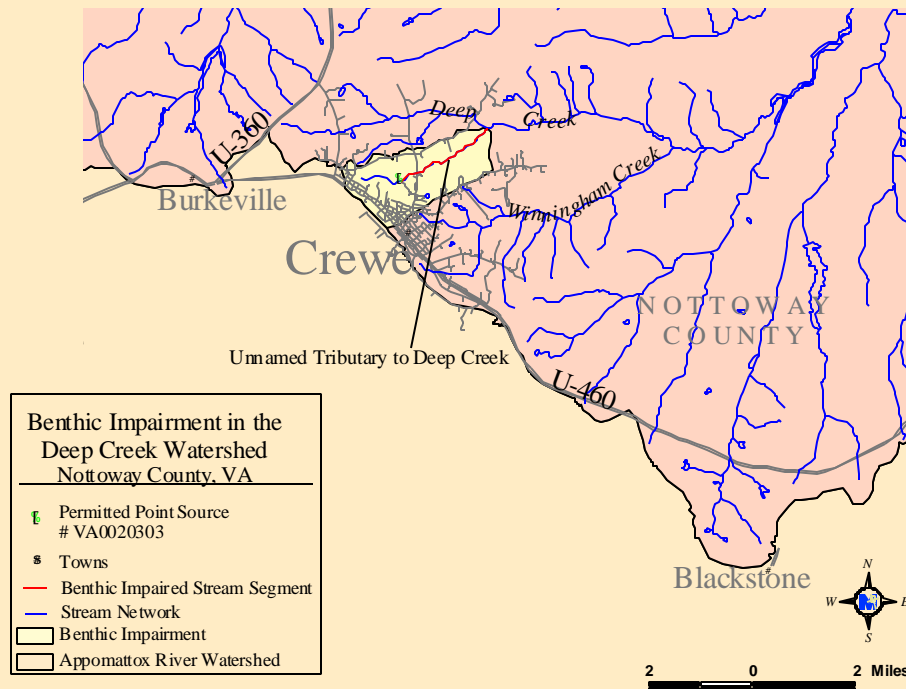
The Lower Appomattox River

There are 11 impaired segments in the lower portion of the watershed:

- 1 segment violating Virginia's General Water Quality Standard (Benthic)
- 10 segments violating Virginia's fecal bacteria standard

The Benthic Impairment

XT Deep Creek – An unnamed tributary to Deep Creek (first-order) passing by the Crewe STP.



General Standard

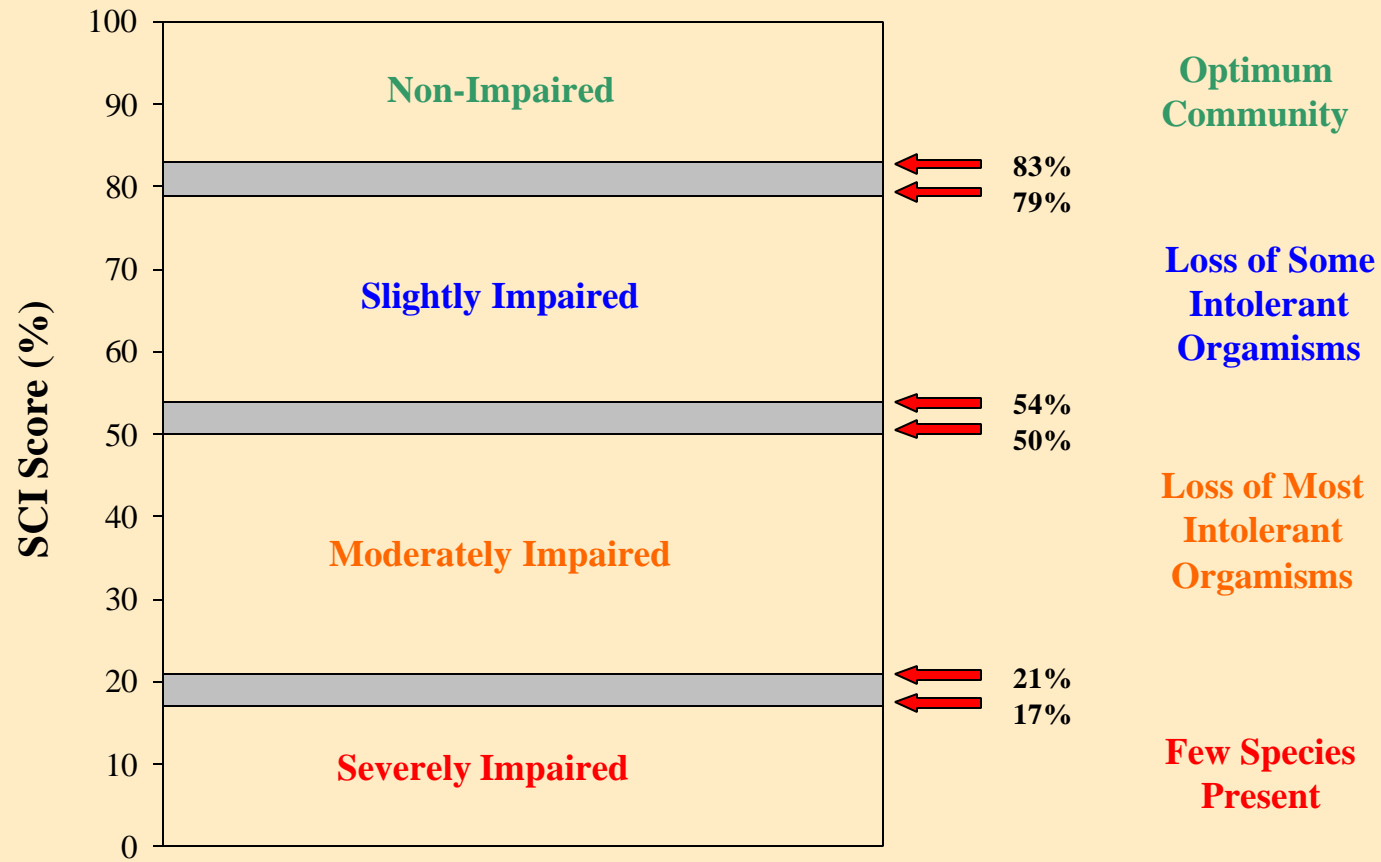
"All state waters shall be free from sewage, industrial waste, or other waste substances ... which are harmful to human, animal, plant, or aquatic life"
(9 VAC 25-260-20)

Stressor Identification

Stressors identified in the Unnamed Tributary to Deep Creek include:

- *Sub-optimal natural habitat*
- *Overflows from the Town of Crewe Sewage Treatment Plant*

Interpretation of Stream Condition Index (SCI) scores



SCI scores for XT Deep Creek

Collection		Impaired Station		Upstream Reference	
Year	Month	SCI	Condition	SCI	Condition
1994	November	6.2	SI	37.0	MI
1995	May	12.3	SI	18.3	SI-MI
1996	May	6.6	SI	38.2	MI
1996	October	NA	NA	24.3	MI
1996	November	11.2	SI	11.4	SI-MI
1997	May	16.2	SI	41.1	MI
1997	November	26.0	MI	44.4	MI
1998	May	22.4	MI	37.0	MI
2002	June	27.3	MI	43.0	MI
2002	September	33.4	MI	33.8	MI

General Quality Allocations

Average annual loads of raw sewage allocated to XT Deep Creek.

Source	Load (kg/yr)
WLA ¹	0
LA	0
MOS	<i>Implicit</i>
TMDL	0

¹ The only point source permitted in the drainage is the Crewe STP (VPDES # VA0020303).

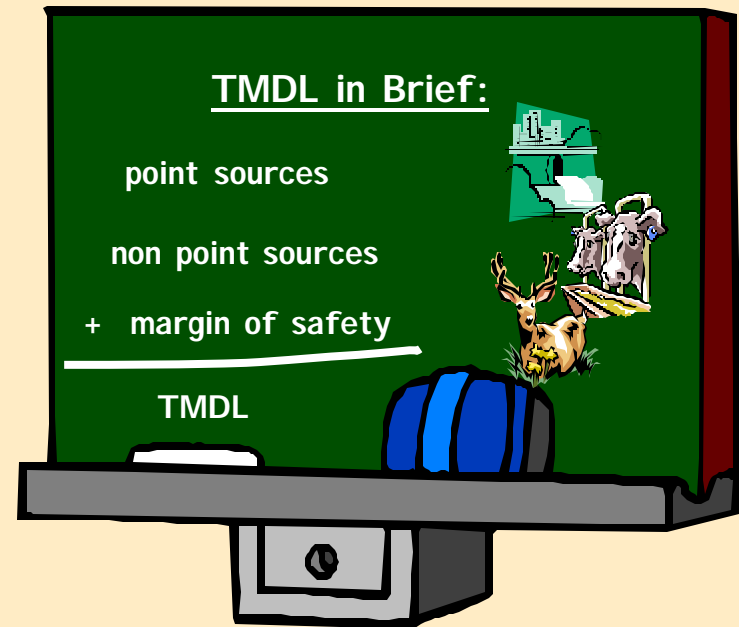
Fecal Coliform Impairments

- 10 segments violating Virginia's fecal coliform instantaneous standard in the Lower portion of the watershed

Impairment	Station	Count (#)	Minimum (cfu/100ml)	Maximum (cfu/100ml)	Violations ¹ (%)	Violations ² (%)
Appomattox River (1)	2-APP118.04	107	17	16,000	19	28
Appomattox River (2)	2-APP012.79	140	18	16,000	12	27
Appomattox River (3)	2-APP001.53	145	18	9,200	10	21
Deep Creek	2-DPC005.20	57	18	16,000	11	25
Flat Creek	2-FLA001.95	58	78	16,000	21	40
Nibbs Creek	2-NBB003.65	44	20	5,100	16	50
Swift Creek (1)	2-SFT036.00	58	18	4,000	10	14
Swift Creek (2)	2-SFT019.15	40	18	16,000	10	13
Swift Creek (3)	2-SFT004.92	54	18	16,000	9	20
West Creek	2-WET004.96	22	45	16,000	14	41

Fecal Bacteria TMDL Development

- Source Assessment
 - Bacterial Source Tracking
- Modeling
 - Hydrology
 - Water Quality
- Load Allocation



Source Assessment

Process of quantifying all major sources producing bacteria and determining delivery mechanism carrying bacteria to stream.

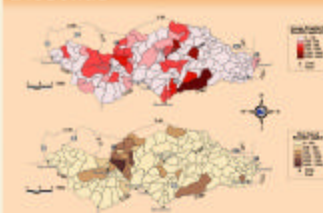
■ Identification, quantification and delivery mechanisms

- Permitted discharges
- Human
- Pets
- Livestock
- Wildlife

Source Assessment: Fecal

Source assessment is the process of quantifying all major sources producing bacteria in a watershed and determining delivery mechanisms carrying the bacteria to the water body. For each source, daily fecal production is multiplied by fecal coliform density to determine the number of fecal coliform each source produces in a day. The numbers of fecal coliform are spatially and temporally distributed throughout the watershed as land-applied loads or direct inputs to the stream.

Biosolids



- Information obtained from Virginia Department of Health
- 23 wastewater treatment plants in the watershed
- Fecal coliform density determined for each source using calibration
- Permitted density for Class B biosolids used for future projections
- Land-applied on pasture and cropland

Watershed	Human Population (2000)	Acres Applied (1997-2000)	Dry-Ton Applied (1997-2000)
Spring Creek	1,120	0	0
Wolf Creek	1,120	0	0
Wolf River (1)	1,120	0	0
Wolf River (2)	1,120	0	0
Wolf River (3)	1,120	0	0
Wolf River (4)	1,120	0	0
Wolf River (5)	1,120	0	0
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Wolf River (14)	1,120	0	0
Wolf River (15)	1,120	0	0
Wolf River (16)	1,120	0	0
Wolf River (17)	1,120	0	0
Wolf River (18)	1,120	0	0
Wolf River (19)	1,120	0	0
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Wolf River (29)	1,120	0	0
Wolf River (30)	1,120	0	0
Wolf River (31)	1,120	0	0
Wolf River (32)	1,120	0	0
Wolf River (33)	1,120	0	0
Wolf River (34)	1,120	0	0
Wolf River (35)	1,120	0	0
Wolf River (36)	1,120	0	0
Wolf River (37)	1,120	0	0
Wolf River (38)	1,120	0	0
Wolf River (39)	1,120	0	0
Wolf River (40)	1,120	0	0
Wolf River (41)	1,120	0	0
Wolf River (42)	1,120	0	0
Wolf River (43)	1,120	0	0
Wolf River (44)	1,120	0	0
Wolf River (45)	1,120	0	0
Wolf River (46)	1,120	0	0
Wolf River (47)	1,120	0	0
Wolf River (48)	1,120	0	0
Wolf River (49)	1,120	0	0
Wolf River (50)	1,120	0	0

Permitted Discharges



- OGC provides the list of permitted facilities with design information and historical monitoring data
- General trend as related to fecal coliform values using monitored data
- Historical data used during model calibration period
- Facility design values used during allocation
- Input as direct load to stream

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Wolf River (41)	1,120	0	0
Wolf River (42)	1,120	0	0
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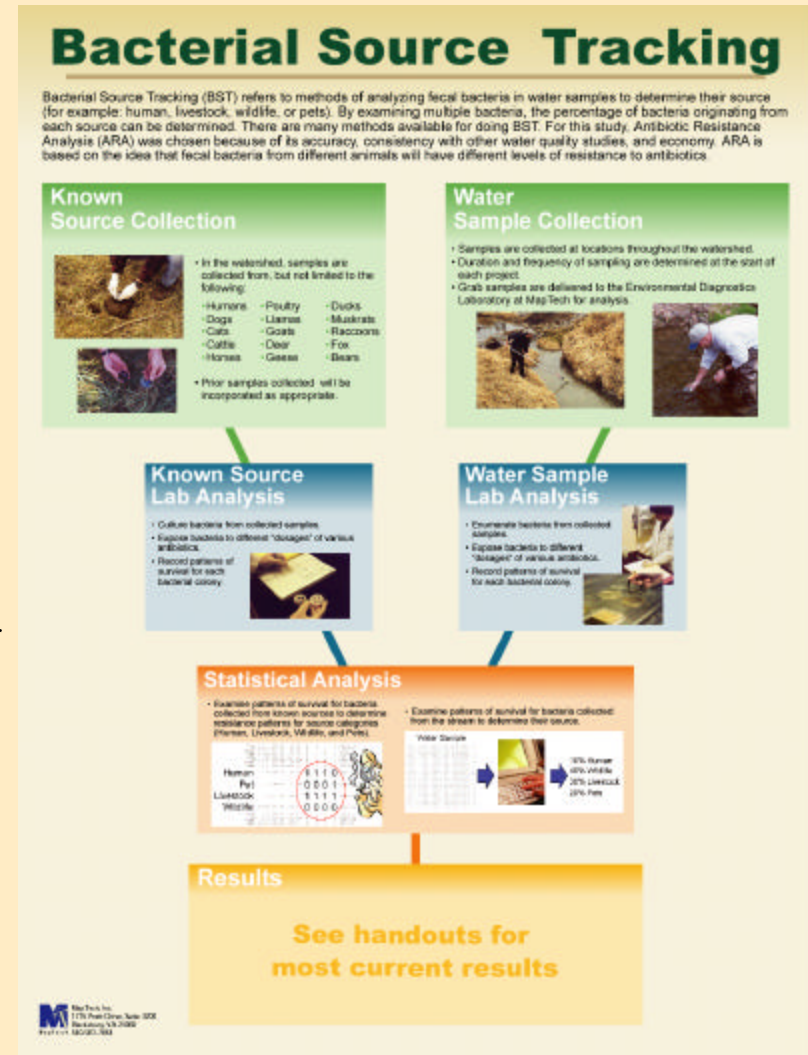
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Bacterial Source Tracking

Laboratory method of analyzing fecal bacteria in water samples to determine their source (e.g. human, pets, livestock, or wildlife).

- Monthly Samples Collected for 1 Year
- Useful Tool for Assessing the Sources of Fecal Contamination
- Should Be Considered in Conjunction with Other (Field) Data



Bacterial Source Tracking - Results

Station ID	Stream	Wildlife	Human	Livestock	Pet
2APP001.53	Appomattox River	17%	5%	50%	28%
2APP012.79	Appomattox River	21%	10%	46%	23%
2APP050.23	Appomattox River	17%	7%	55%	21%
2APP068.93	Appomattox River	26%	6%	40%	28%
2APP090.12	Appomattox River	18%	12%	52%	18%
2DPC005.20	Deep Creek	16%	9%	59%	16%
2FLA001.95	Flat Creek	24%	8%	53%	15%
2NBB001.54	Nibbs Creek	22%	6%	57%	15%
2NBB003.65	Nibbs Creek	19%	12%	58%	11%
2SFT004.92	Swift Creek	12%	10%	51%	27%
2SFT019.15	Swift Creek	28%	16%	41%	15%
2SFT036.00	Swift Creek	34%	8%	24%	34%
2WET004.96	West Creek	24%	3%	60%	13%

** Percentages given are weighted averages from multiple BST samples.*

Modeling

Establishes relationship between in-stream water quality and source loadings.


- Model set-up
- Calibration
 - Hydrology
 - Water quality

Modeling

Modeling establishes the relationship between in-stream water quality and source loadings, allowing evaluation of management options that will achieve the desired water quality endpoint. The relationship is based on data collected throughout the impaired watershed. Monitored flow and water quality data is then used to verify that the relationships developed are accurate. The USGS Hydrologic Simulation Program-Fortran (HSPF) water quality model and the USEPA Water Quality Analysis Simulation Program (WASP) coupled with the Link-Node Tidal Hydrodynamic Model (DYNHYD) were chosen as the modeling framework to simulate the hydrologic and water quality interactions for modeling fecal contamination.


Models

- Continuous simulation model
- Account for point and nonpoint source loadings
- Watershed divided into subwatersheds
- Total section divided into channel segments and nodes



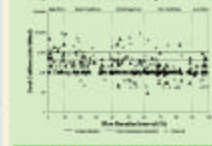
Calibration

- Process of adjusting model parameters within physically defensible ranges until the resulting predictions give a best possible fit to observed data
- Compensates for uncertainty
- Precipitation and flow stations
- WQDC hourly and daily precipitation
- USGS daily stream flow stations
- Installed stage recorder

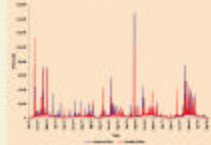


Critical Period Analysis

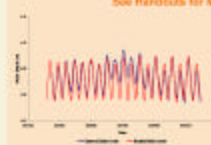
- Modeling period selection based on availability of data and representation of critical hydrological conditions
- Graphical and statistical analysis



Hydrology Calibration Results



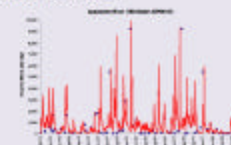
See Handouts for Most Current Results



- Comparison between modeled versus observed stage for:
 - Baseflow
 - Storm peaks
 - Mean lower low water

Water Quality Calibration

- Components needed to represent source loadings outlined on the "Source Assessment" poster
- Visual inspection of graphical comparisons between continuous model results and observed points will be primary tool to guide calibration process
- Standard error calculation will be used to measure the variability of the sample mean of the modeled values about an instantaneous observed value



See Handouts for Most Current Results

Load Allocation

Determine waste load and load allocations along with margin of safety for a reduction scenario that meets WQS

- Develop load reduction scenarios
- Model scenarios
- Select a scenario that meets WQS as the TMDL

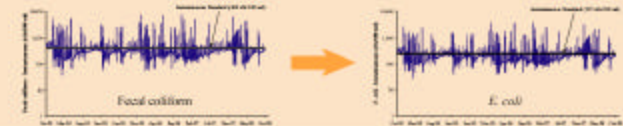
Allocations

The TMDLs developed for the Appomattox River watershed were based on the Virginia State Standard for *E. coli*. The *E. coli* standard states that the calendar month geometric mean concentration shall not exceed 126 cfu/100 ml and that maximum single sample concentrations of *E. coli* shall not exceed 235 cfu/100 ml.

Fecal Coliform to *E. coli* Conversion

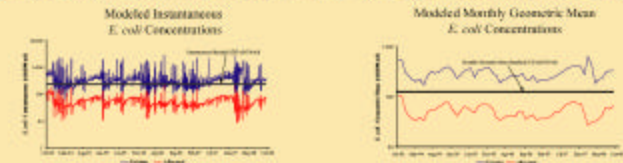
- According to the guidelines put forth by USEPA for modeling *E. coli* with HSPH, the model was set up to estimate loads of fecal coliform, then the model output was converted to concentrations of *E. coli* through the use of WQS's fecal-coliform-to-*E. coli* formula:

$$\log_2(C_{ec}) = -0.0172 + 0.91905 \cdot \log_2(C_{fc})$$



Existing and Allocated Conditions

- Pollutant concentrations were modeled over the entire duration of a representative modeling period, and pollutant loads were adjusted until the standard was met.



Scenarios Allocation

- The development of allocation scenarios was an iterative process that required numerous runs with each followed by an assessment of source reduction against the water quality target.

Example Scenario Contributed by Sources (cfu/100 ml)

Source	Mean	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1	10	10	10	10	10	10	10	10	10	10	10	10
2	10	10	10	10	10	10	10	10	10	10	10	10
3	10	10	10	10	10	10	10	10	10	10	10	10
4	10	10	10	10	10	10	10	10	10	10	10	10
5	10	10	10	10	10	10	10	10	10	10	10	10
6	10	10	10	10	10	10	10	10	10	10	10	10
7	10	10	10	10	10	10	10	10	10	10	10	10
8	10	10	10	10	10	10	10	10	10	10	10	10
9	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10

- To meet the standards the scenario must result in zero violations of both *E. coli* standards: calendar month geometric mean and single sample maximum. In the example above, Scenario 5 achieves zero percent violations in which both standards are met.

See handouts for final scenarios

TMDL

- The Total Maximum Daily Load (TMDL) is the maximum amount of *E. coli* that the stream can assimilate and still maintain the *E. coli* standards previously mentioned. All sources are considered and control of the following:

- Waste Load Allocations (WLA) = Point Sources
- Load Allocations (LLA) = Nonpoint Sources
- Margin of Safety (MOS) = Implicit accounting of uncertainties

- Permitted sources are allocated their design flow capacity of a concentration of 128 cfu/100 ml.

- The TMDL is expressed in terms of colony-forming units delivered to the outlet of the impairment per year.

See handouts for TMDL load allocations

Load Allocations – Stage I/Management Scenarios

Reduction percentages for the Stage I implementation.

Impairment Name	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access/ Cropland	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	% Single Samples Exceeding 235 cfu/ 100ml
Appomattox River (1)	0	0	90	50	50	100	14.03
Appomattox River (2)	0	0	90	50	50	100	11.89
Appomattox River (3)	0	0	0	50	50	100	12.5
Nibbs Creek	0	0	90	50	50	100	12.42
Flat Creek	0	0	90	50	50	100	12.6
West Creek	0	0	90	50	50	100	24.82
Deep Creek	0	0	90	50	50	100	24.71
Swift Creek (1)	0	0	90	25	25	100	5.86
Swift Creek (2)	0	0	75	45	45	100	9.97
Swift Creek (3)	0	0	25	45	45	100	9.75

Load Allocations – Example Scenarios for Appomattox River Watershed

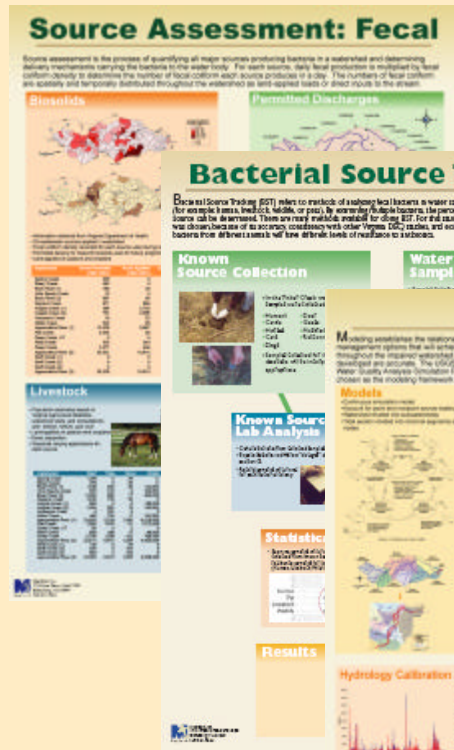
Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	33.33	17.7
2	0	0	100	100	100	100	20	2.58
3	0	0	90	50	50	100	23.33	7.51
4	0	0	50	50	50	100	25	9.7
5	30	0	100	80	80	100	13.79	3.55
6	38	78	100	99	99	100	0	0

Load Allocations – the TMDLs

Impairment	WLA (cfu.year)	LA (cfu/year)	MOS	TMDL (cfu/year)
Appomattox River (1)	4.74E+12	6.86E+14	<i>Implicit</i>	6.90E+14
Appomattox River (2)	1.40E+13	5.87E+14		6.01E+14
Appomattox River (3)-tidal	9.62E+13	1.02E+15		7.85E+14
Deep Creek (FC)	1.38E+12	1.05E+14		1.06E+14
Flat Creek	8.32E+11	8.72E+13		8.80E+13
Nibbs Creek	8.32E+11	1.20E+13		1.29E+13
Swift Creek (1)	8.37E+09	2.01E+13		2.01E+13
Swift Creek (2)	3.80E+11	8.38E+13		8.42E+13
Swift Creek (3)	5.82E+11	1.28E+14		1.29E+14
West Creek	0.00E+00	3.91E+13		3.91E+13

* All loads presented in the TMDL table are given in cfu/year for *E. coli*

Poster Session



Rod Botkin

Jim Kern

Alan Foster

Megan Laird

Contact Information

- Phillip McClellan, MapTech
 - 1715 Pratt Drive – Suite 3200
 - Blacksburg, VA 24060
 - 540-961-7864
 - Email pmcclellan@maptech-inc.com
 - Web <http://www.maptech-inc.com>

- TMDL Documents
 - Chris French, DEQ TMDL Coordinator
 - Piedmont Regional Office
 - 804-527-5124
 - Email rcfrench@deq.state.va.us
 - Web <http://www.deq.state.va.us/tmdl/>

